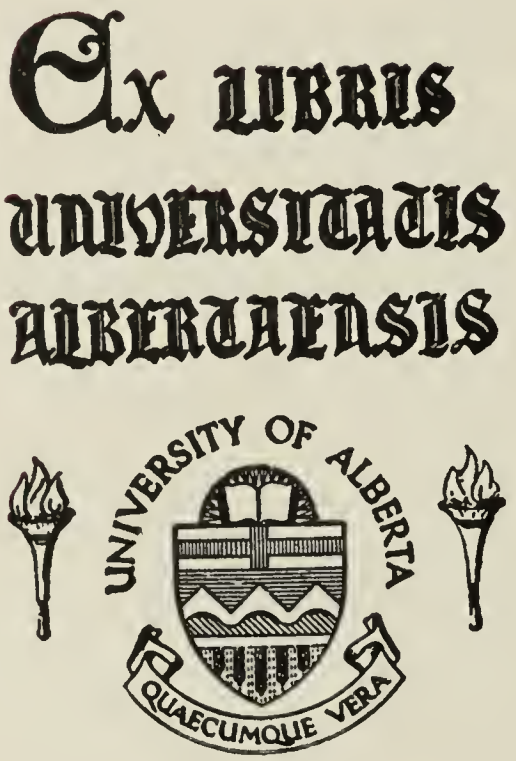

University of Alberta
Printing Department

UNIVERSITY OF ALBERTA

THE MENTAL AND PHYSICAL SEQUELAE OF PREMATURITY

by

DAVID AUBREY BELL

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF EDUCATION

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

MAY, 1965

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The Undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "The Mental and Physical Sequelae of Prematurity", submitted by David Aubrey Bell in partial fulfillment of the requirements for the Degree of Master of Education.

Abstract

The purpose of this study was to investigate the intelligence rating of a group of ten year old, low birth weight children. The physical development of these children was also considered. These factors were considered in relation to parental age, education, salary; as influenced by home environment and degree of low birth weight.

The literature demonstrated that the age of testing of low birth weight children has a definite bearing upon the intellectual rating. There are many other factors besides low birth weight such as ante- and post natal care that influence the mental development of these children. The socio-economic status of the parents also has a marked effect upon these children.

The physical development of low birth weight children is strongly affected by their social and economic environment. The increased incidence of illness and physical deformity is correlated directly with actual birth weight of the child, in that the lower the birth weight the greater the amount of illness and deformity found in these children.

The sample of children used in this study were drawn from the records at the Hospital of the University of Alberta. The intellectual test used was the Wechsler Intelligence Scale for Children. The physical examination was carried out by a

Abstract (Continued):

team of doctors at the University Hospital, and was standardized as much as possible.

The analysis of the data showed that the birth weight of the sample showed no significant relationship with the I.Q. of the children. The home environment and physical development had no significant relationship with the I.Q. of the children. The incidence of inadequate physical development, physical deformity and an increased incidence of illness were not found in this sample.

The low birth weight children, at ten years of age, performed equally well on intelligence tests, when compared to the children of average birth weight. The implications were that as there is no significant difference between low birth weight children and children of normal birth weight, they should therefore be brought up under similar circumstances. The causes of prematurity were not considered in this study.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF TABLES--CONTINUED

CHAPTER I

FACTORS OF LOW-BIRTH WEIGHT CHILDREN

I. INTRODUCTION

The term 'prematurity' although conveying the impression of low birth weight, functional immaturity and the possibility of subsequent abnormality, does not describe any clear cut entity.

The definition of just what a "premature child" connotes is a controversial matter. The World Health Organization (1961) classifies a live born infant with a gestation period of 37 weeks or less as being premature, or equivalent to an immature infant which is a live born infant with a birth weight of 5 1/2 lbs. (2,500 grams) or less. The American Academy of Pediatrics (1964) has classified a live born infant with a birth weight of 5 1/2 lbs. (2,500 grams) or less to be a "low birth weight" child, regardless of the length of gestation period. This organization has dropped the terminology of children being premature. This study will adopt the definition "low birth weight" and use it as described by the Academy.

The number of low birth weight children is significant in our population. Spohn (1950) found that seven per cent is the average number of low birth weight children of all live birth children, per year, in Canada.

The literature on the effects of low birth weight is of a very conflicting nature. Hebb (1934) states that premature birth unassociated with intracranial injury does not affect mental development. This opinion has been frequently repeated; eg. Beskow (1949), Alm (1953), Douglas (1956).

Knoblock and Pasamanik (1962) write

> Almost all medical literature still equates failure to breath at birth with birth injury, placing the damage at the time of delivery. This evidence suggests that pre-existing brain damage interferes with the ability to adjust to extra-uterine life and to initiate respiration.

They go on to state that the new born infant has remarkable resistance to anoxia in absence of pre-existing damage.

In Edinburgh, Drillien (1963) found that the control group of average birth weight children up to five years of age showed little evidence that complications of pregnancy and/or delivery had any affect on later intellectual functioning; although in both average and low birth weight groups of children such complications were significantly associated with an increased incidence of behaviour disturbance. It would appear from the above work that brain damage seldom occurs during birth and that most failures to breathe occur because of damage in the intra-uterine passage.

Illingworth (1963) suggests that the intellectual testing of children up to five years of age is of great value in the

detection of mental retardation and neurological abnormality, though he has found little evidence that mental superiority can be detected in infancy. Drillien (1964) reports that when children of low birth weight are compared with mature children (children with a birth weight of over 2,500 grams) regardless of the length of gestation, they display an average lower intelligence rating at five to seven years of age. Douglas (1956) also found that low birth weight children at seven years of age had a lower intelligence rating by the method he used for evaluating his sample. The method of evaluating seems to enter the work of each of these researchers. Perhaps it is the method of evaluating that varies because each investigator used a different form of test, all supposedly measuring I.Q.

Hebb (1944) has suggested that the I.Q. score can be made only when the social background of the subjects compared are identical; and this adds up to the proposition that we cannot, in any rigorous sense, measure a subject's innate endowment, for no two social backgrounds are identical. Similarly, we do not know what the important environmental variables are in the development of intellectual functions. Innate intelligence may sometimes be estimated, but it cannot be measured. The physical condition of the child does not indicate the intellectual rating.

The factor of experience also affects the I.Q. rating of the child; for example, Binet (1905) assumed the necessity of adequate experience in the subject to be examined by his methods. Drillien and Illingworth have determined the mentally retarded and sub-normal children, below five years of age by using intellectual tests, such as the Terman-Merrill "L" Form scale. This type of test was acceptable to the child, as well as the mother because absolute failure was impossible. Drillien was measuring psycho-motor ability at this age, for of necessity the test is largely non-verbal below six years of age.

Another factor that prominent testers have discovered affecting the I.Q. score is personality. Wechsler (1950), whose tests are used to evaluate the intellectual ability of the sample in this study, states that: "personality traits enter into the effectiveness of intelligent behaviour and hence into any global concept of intelligence itself." The educational attainment of children is not correlated very closely with I.Q., or with physical condition. Such factors as the social back-ground, experience, and personality all exert a powerful influence on the I.Q. rating and they also strongly affect the educational attainment. The older child does appear to have more factors which complicate the issue in obtaining a reliable and valid I.Q. rating. But when the experience, personality,

and social background are all considered, is it the child or the test that varies so much in giving I.Q. ratings? If there is an overlay of brain damage before, during or after birth, and all other factors are equal, does time change the effects of brain damage? Perhaps time is a more important factor than any of the above factors in helping low birth weight children catch up to their peers in intellectual ratings.

There has been a large number of studies made in an effort to determine the mental development of low birth weight children. Benton (1940) published a critical review of American and European studies made since 1911, and reported a wide divergence of opinion in the published literature. He suggested that the discrepancies were the result of the following:

1. Use of clinical impression, and other subjective criteria instead of standardized tests.
2. Little attention being paid to the socio-economic character of the children under study.
3. Inadequate numbers and unsatisfactory controls.
4. The selective nature of the sample.

In this study actual measurements and standardized tests will be used to counteract the impression and subjective criteria as much as possible. Sufficient numbers will be used to obtain significant results. Many of the first born children

of very young mothers are often of low birth weight. The socio-economic character of the children's homes will be taken into consideration, as well as it can be gauged by a questionnaire.

The research appears to point out that low birth weight children differ from average birth weight children. The degree of difference appears greatest just after birth and gradually disappears, but some difference has been found at seven years of age. The social background, personality and experience all affect intellectual rating, but these factors largely appear after the child enters school. The physiological factor of the new born low birth weight child appears to be the greatest factor in determining the intellectual ability of the child. If brain damage is present it appears to show up to the greatest extent at this age. The work of other investigators stresses a difference of one standard deviation in I.Q. between the two groups of children. This is particularly predominant up to seven years of age, but thereafter it becomes rather controversial.

II. THE PROBLEM

The primary purpose of this study is to investigate the intelligence rating of a group of ten year old, low birth weight children. The secondary purpose is to investigate the physical

development of those same children. The correlation of low birth weight, home environment and factors such as parental age, salary, and the occupation of the parents will also be considered.

III. THE HYPOTHESES

On the basis of the relevant literature, the following hypotheses will be formulated:

1. That low birth weight children at ten years of age will make lower scores on the Wechsler Intelligence Scale for Children than a group of normal birth weight children.
2. That the birth weight of low birth weight children is correlated with the I.Q. Score.
3. That the development of low birth weight children will be a function of their home environment as measured by such factors as economic level, parental grade accomplishment and parental occupation.
4. That low birth weight children have a higher incidence of inadequate physical development, physical deformity and an increased incidence of illness than do normal birth weight children of the same age.

CHAPTER II

THE MENTAL DEVELOPMENT OF LOW BIRTH WEIGHT CHILDREN

A review of the literature is presented to support the first and second hypotheses of this study. Intellectual capacity and development appear to be hindered by prematurity, but there are other factors such as age at testing, testing instruments, as well as differences in samples that also affect intelligence ratings.

There has been a large number of studies made to determine the mental development of premature children. Benton (1940) published a critical review of the American and European research starting in 1911. He reported a wide divergence of opinion in the published literature, with no conclusive evidence.

The literature surveyed is presented chronologically so that some of the factors causing differences between infants, school children and adults can be compared when their birth weights are considered. For example, Knoblock et al (1956) gave the Gesell developmental tests to 992 infants at forty weeks of age. This sample consisted of five hundred premature children and 492 full term controls who were matched on the basis of race, season of birth, parity (birth order), hospital of birth and the socio-economic status. Fifty-six of the children

weighed 1,500 grams or less at birth. This study revealed a relationship between prematurity and lowered intellectual potential at forty weeks of age. These conclusions were confirmed by repeating the examination of nine hundred of these children at three to four years of age. The proportion of the dull normal, borderline defective and defective categories was greater than in the full term group of children. The children with the lowest birth weight (1,500 grams or less) were disproportionately represented in all the below average categories. The subdivision of low birth weight children at the 1,500 gram level does appear to be a significant factor in separating defective children from the normal.

In another study by Drillien (1959) an arbitrary birth weight level of 2,000 grams was used. Her sample consisted of 595 premature and full term children. The mental development of these children was assessed at six month intervals up to the age of two years. The observed developmental level was related to birth weight at all ages. It was found at two years of age there was a high proportion of dull, retarded and grossly defective children in the birth weight group of 2,000 grams or less. There appears to be a cut-off point in birth weight where a major difference appears in the mental and physical condition of these infants.

Dann (1964) used yet another weight level. He carried out a follow-up study of premature children with birth weights from 660 to 1,280 grams. He found that at four years of age the intellectual quotients ranged from 59 to 142 with an average of 94 in a sample of 73 children. He used a control group of full term siblings in which the I.Q. ranged from 70 to 137, with an average of 107. He found no apparent relationship between the I.Q.'s of the prematurely born children and the following factors: year of birth, maternal illness, complications of pregnancy or delivery, birth weights, neonatal complications, jaundice, and the presence of visual or other physical defects.

Dann (ibid.) also found that socio-economic status appeared to play a role; for example, among 47 of the private patients 22 had I.Q.'s of 100 or more, whereas only five of the 26 Out-Patients had I.Q.'s of 100 or more. The generally high socio-economic status of the families was thought to explain the difference between the observations in this study and those of Knoblock et al (1956), Douglas (1956), Drillien (1959) and others who reported a high incidence of mental and neurological handicaps in the prematurely born children.

The intelligence rating of school age children was investigated by Asher and Roberts (1949). They tried to find a correlation between birth weight and the intelligence of school children, by using the birth weight and I.Q. of 4,800 children

attending regular school in England. They also considered 877 children in special schools for the educationally sub-normal. The children found to be certified as mental defectives had a lower mean birth weight than the normal birth weight children. They found four times as many children with low birth weight (below 1,247 grams for girls and 1,447 grams for boys) among the children who were mentally below normal as there were among the mentally normal children. They attributed this high proportion of sub-normal and mentally defective children to an excess of very low birth weights among the children.

The intelligence rating of the children can vary for numerous reasons so Blegen (1953) tried some other types of tests. He examined the scholastic records of 150 premature children who had completed their primary schooling, as well as the records of a corresponding number of mature children. In the practical subjects such as sewing, woodwork and metal work, the achievement was similar in the two groups. However, in the scholastic subjects the prematurely born students appeared to be at a disadvantage. In line with the same type of investigation, Eames (1955) studied the speed of seeing and recognizing objects and words, in a sample of 25 school children whose birth weights were 2,500 grams or less. He also used an equal number of mature controls. The words and objects were projected on a screen

for varying time periods; the speed was gradually reduced until the child was just able to recognize the test subject. As compared with the mature children, the premature group recognized objects and words much more slowly. The results of the studies suggested that prematurity was an important factor or handicap to learning.

Another type of testing was carried out by Douglas (1956) in England. His study was made up of three evaluations of the same sample; a form of longitudinal study. When his sample was eight years old, he tested the low birth weight children for reading, word comprehension (vocabulary) and the ability to appreciate relationships (picture intelligence). These tests were specifically designed for this study. The premature children scored lower than their controls in each of the tests. The greatest handicap appeared in the reading tests. Douglas noted that there was a small group that made outstandingly poor scores in all the tests. The effects of prematurity in these individuals was unexplained by obstetric abnormalities such as toxemia, antepartum hemmorrhage, and induction of labor, or by the small stature of the parents. However, after this group was excluded from among the premature children of this sample, they still showed a slight, but significant, handicap in reading and picture intelligence, although not in vocabulary.

In subsequent investigations of the mental ability and primary school progress of these same children, Douglas (1959) found handicaps in the premature group which appeared to be more environmental in origin, rather than the result of low birth weight. He found that by dividing the environmental background of the children into various social levels that the standards of care and educational interest were lower, per social level, among the premature children than among the control group of children. The scaling of social status into various levels is always a very controversial point, so much so that Douglas was not too convinced as to the effectiveness of his methods.

There was another group of investigators at the Colorado General Hospital who attempted to examine the influence of social status upon the development of premature children. They also considered many other factors. Lubchenko et al (1963) carried out a follow-up study with 100 premature children of birth weights 1,500 grams (3 lbs. 4 oz.) or less. Ten years later they could only find 63 of their original sample to carry out a complete examination. This included medical and neurological examinations, psychological testing, electroencephalography, and an evaluation of the social situation of the families of the patients.

Lubchenko found that premature children of very low birth weight, that is, less than 1,500 grams, had a very

high incidence of central nervous and visual handicaps. The incidence and severity of handicaps was inversely related to the weight at birth. Difficulties during the neonatal period were also inversely related to birth weight, while obstetrical complications and oxygen administration showed no correlations. They found that in many cases growth retardation was severe; social and emotional problems were also encountered. They also found thirty per cent school failures among these premature children with normal intelligence.

The intelligence rating was established by use of the Wechsler Intelligence Scale for Children, (WISC), a standardized individual I.Q. test of general use today throughout the English speaking world. Lubchenko found by use of the WISC that two-thirds of children made discrepant scores of ten points or more between the verbal and performance items on the WISC. But, they also found that there was no relationship between discrepant scores and school failures. This group of investigators also found that reading difficulties, problems with numbers, speech disorders and emotional disturbances were common problems among these low birth weight children. They found, too, that 60 per cent of the children had abnormal electroencephalographic readings in contrast to six per cent incidence in children of full term birth.

Lubchenko et al raised this pertinent question: Has there been an actual increase in the incidence of handicapped

premature infants in recent years, and are different types of defects noted in premature infants cared for in different centres? If such questions are answered in the affirmative, then investigation of postnatal influences becomes even more important than it has been in the past.

Coming closer to home, Rabinovitch (1961) in Montreal made a study of fifty male premature children and a randomly selected control, also males. The birth weights of his prematures varied from 1,500 to 2,250 grams at birth; the highest low birth weight children so far encountered in this review. He divided his sample into two groups; a form of longitudinal study, one being investigated at seven years of age and the other group at eleven years. He had hoped to show that the two age groups would have a developmental deviation that showed up in the seven year old premature group that had disappeared by the time they reached eleven years of age.

Rabinovitch also used the standardized WISC test and found that his control groups had an average intelligence quotient of 116, while that of both his premature groups had 108. When his data was subjected to statistical analysis, it was found that the difference of eight points was significant. Further analysis indicated very clearly that there was a greater discrepancy between the older group of controls and the older

premature group than was the case among the younger groups. In further testing they found that there were reliable differences between premature and full term children in areas of general intelligence, sensory-motor co-ordination, and also in certain aspects of perceptual functioning, all in favor of the control group at each age level.

The scores obtained by the control group in Rabinovitch's study are very interesting when compared to those obtained by Dockrell (1962) in Edmonton on a study of randomly selected ten year old children. Dockrell found that the Edmonton sample scored significantly higher on the WISC than do American children of the same age. The mean full scale intelligence quotient of the Edmonton sample was more than one standard deviation above one hundred. He suggested that some of the differences arose from the Edmonton sample being wholly urban, as well as being made up of a Northern population whereas Wechsler's original standardization group was drawn from the southern part of the United States and was partially rural. The advent of television as well as more emphasis being placed on education in the last twelve years could also affect these scores. Edmonton is also a city without a lower-lower class as found in many American cities, and the sample was drawn from public school children only. These factors could all have an effect upon raising the mean I.Q. of the Edmonton sample over that of Wechsler's group.

The factor of the age of the premature child when tested for physical and mental attainment has been developed throughout the review of the literature. To carry this forth Knoblock et al (1956) completed a study on some fourteen year old low birth weight children from Maryland at the Johns Hopkins University. This was a longitudinal study of premature and mature controls born in 1952. An estimate of the integrity of the nervous system was made on the basis of the presence or absence of impairment in neuromotor functions and deviations in muscle tone. They found in the premature group of children a lower proportion of normal infants and a higher incidence of neurological defects than in the full term controls. These groups of children have had three rounds of examinations, but the results are not yet published for the third round.

The final round in this age factor was examined carefully by Alm (1953) who did a follow-up study on a group of nearly 1,000 premature and mature children, upon reaching adulthood. Alm picked a sample whose initial social status was not markedly poor. He found that the premature children as adults constituted no greater burden on the community than did the control group. In many ways, they had done as well in social adaptation as the control group.

Table No. 1 from Alm (ibid.) presents some interesting material on a longitudinal study of prematures and a control group

TABLE 1

A FOLLOW-UP IN 1948 OF PREMATURE MALES AND FULL TERM CONTROLS BORN IN STOCKHOLM IN 1920-21

	% of Prematures		Controls
	Single Born (N=759)	Plural Born (N=240)	Single Born (N=981)
Mental Development Disturbances:			
Pupils in special classes	3	6	2
Institutional care	5	2	1
Spastic paralysis, epilepsy, etc.	4	3	1
Fitness for Military Service:			
Fully fit for active service	56	63	64
Unfit for active service	17	15	13
Military promotion of those fully fit	15	5	12
Social and Economic Progress:			
Group I (higher officials, directors, etc.)	10	11	12
Group II (foremen, office workers, etc.)	46	50	44
Public relief:			
Unemployment relief	17	21	15
Poor relief	20	22	22
Sickness relief	17	23	18
Median Net Income (crowns)	6080 cr.	5900 cr.	6270 cr.
Conviction for crime	6	4	9
Conviction for drunkenness	11	15	11

all interlaced with such factors as very low birth weight, socio-economic status, ante- and postnatal care, as well as birth order in the particular family. There are also other factors that will be considered in the next chapter covering the physical development of the low birth weight children.

CHAPTER III

THE PHYSICAL DEVELOPMENT OF PREMATURE CHILDREN

There have been many long term studies of the physical growth of premature children in the last forty years. Alm (1953) prepared a monograph of a critical survey of the publications between 1913 and 1952. The results of these studies are conflicting, and there is still considerable controversy concerning the physical progress of premature children.

Douglas and Mogford (1953) offer a possible explanation for the confusion. They suggest that the following are some of the reasons it is so hard to find a control population: Premature children tend to be female, to be the first born child, to come from poorer classes, and to have mothers whose age is different from the average age for childbearing. Unless they are compared with mature children chosen to conform with these patterns, it is difficult to interpret the results. Since there has been considerable variation in the concept of the control population in published studies, it is not surprising that the conclusions from follow-up studies have not been uniform.

One of the first studies of growth of premature infants was published in 1919 by Ylpp'o, who reported the results of repeated weights and measurements of 700 premature infants in four birth weight groups. He found that in the first three

to five years of life the weight and length of nearly all the premature infants remained lower than the weight and length that he had accepted as normal for children of equal gestational age who were mature at birth. The delay in growth among the premature children was inversely proportional to their weight and length at birth.

Drillien (1958) reported a series of follow-up studies of the growth in height and weight of 103 premature infants born in England; 174 concurrent controls were selected in modified random order from the full term population. She found that at any given age in the pre-school period, follow-up weights continued higher among the infants with the higher birth weights. A similar trend was observed for follow-up studies of the heights of these same children. Illingworth et al (1950) also observed a correlation between birth weights and the body dimensions of 238 children between the ages of five to eight years.

Douglas and Mogford (1953) found that the mothers of premature children were on the average shorter and lighter than the mothers of the controls. However, the mothers of those premature children who at four and one half years of age had caught up in height and weight were as large as the mothers of the control group infants. They conclude that the height of the mother gave a better indication of the likely growth pattern of her premature

child than did the birth weight, medical history of the pregnancy, or the length of the period of gestation.

Spector (1961) has calculated the 95 per cent range of Canadian children at ten years of age. He found that boys were 53.1 inches in height and weighed 70 pounds. The girls were 53.3 inches in height and weighed 69 pounds. In the same table Spector found that boys at birth weighed 7.8 pounds and had a length of 19.9 inches and that the girls were 7.6 pounds at birth and had an average length of 19.7 inches.

The American white children of the same age are both taller and heavier. For example, the boys at ten years of age were 54.3 inches in height and weighed 70.7 pounds, whereas the girls were 54.2 inches in height and weighed 70.3 pounds. This may be part of the reason why so many world studies have pointed out that premature children appear to be small in relation to the national norms. The Canadian population is a very similar group to the American group so there must be some other factor influencing the size of the two populations.

Lubchenko (1963) found that premature infants were smaller than the general population during the childhood years and also as adults. The cause for this physical retardation has not been determined. The children in this study were smaller at birth than the weight expected for the length of the gestation period.

They remained relatively small throughout their childhood years. Undernutrition, so common in the first few weeks of the premature infant's life, is appealing as an explanation for growth retardation.

Garn (1959) has found that measuring the parents' physical development as well as that of the individual child adds greatly to the assessment of the child's developmental status. Indeed, he makes a plea for growth charts to incorporate this factor. He suggests that it is timely to teach and accept the idea that an influence on development is not genetic (hereditary) or environmental, for this idea implies two neat "pigeon holes" into which only one must be placed as a particular influence. The two factors are clearly inseparable and interact constantly. It is better to think and speak of the possible influence of these factors.

Tanner et al (1956) found and followed up a group of children until they reached adulthood. These children had their physical growth measured longitudinally for their first five years. This group found that there was no relationship between size at birth and adulthood; but they did find a maximum correlation between birth size and actual size at three years of age. They also found that the rate of growth and size appeared to be independent at any one given time.

In a further study of the first few years of growth and size of infants, Falkner (1957) confirmed the conclusions of Tanner (1956); that at birth the infants' immediate growth is heavily

influenced by pre-natal and maternal factors. These tend to diminish in influence and by two to three years of age the child is on his own largely genetically weighted curve of growth.

The rate of development of children is also affected by nutrition that they receive. Smith (1962) found that in the past, pediatricians have not been greatly worried over the nutrition of premature infants once they have survived the first four or five days of life. Pediatricians knew that the more premature and tiny the infant, the less permanently and completely would be his extrauterine weight-gain matched with what he would have gained by transplacental nutrition. Weight gain matters very little when one is looking only for the survival of the small patient.

The effects on growth by certain environmental and genetic factors have been carefully selected, and much of this information has been submitted to statistical analysis to check for the significance of these factors. The following six factors were gleaned from the work of Drillien (1961):

1. Maternal Efficiency. The mean weights and heights of children at two to four years of age were related to maternal care. The effect of poor care was most marked in those children who were 2,500 grams or less at birth. Twins were affected more than single birth infants and males more than females.
2. Frequency of Illness. The effects of illness on the growth

of low birth weight children was most marked in single birth infants with a birth weight of four and one half pounds and in twins of five and one half pounds, or less.

3. Diet. The children of low birth weight often received an inadequate diet due to the low income of their parents in Scotland, as this was the group that had the highest percentage of premature infants. Drillien found that at four years of age the birth weight still has an independent effect on stature, as she carefully examined a sample of children from the upper income brackets where diet was adequate.

4. Gestation Period. In the birth weight group of four and one half to five and one half pounds and in mature children, lower weight and height increments were recorded at five years of age for those children having a gestation period of thirty-eight weeks or longer than for those with a gestation period of thirty-seven weeks or less.

5. Severe Feeding Problems. No obvious effect of severe feeding problems on growth were found at two years of age. At four years of age some difference was found, particularly in weight increment, between children who had or had not exhibited problems.

6. Maternal Height. Rate of growth increased with height of mother for all grades of maternal efficiency, and decreased with declining standards of efficiency for all heights of mothers.

In summary, Drillien's findings based on correlation and regression analysis were:

1. At two years of age. Factors considered primarily genetic; for example, parental heights, were found to be of approximately equal importance in their influence on growth as were environmental factors such as social class, maternal efficiency, frequency of illness and diet.
2. At four years of age. The correlation between growth increments and environmental factors were highest for those children that were smallest at birth, and higher for premature twins than for single infants.

Drillien (1959) found that the proportion of prematurely born children of small stature, at five years of age, who came from that group of children who were four and one half pounds or less at birth, was one third underweight; that is, measuring less than the fifth percentile for mature children. One fifth were underweight and one sixth were underweight and underheight.

The medical literature supports the hypothesis that low birth weight children are strongly affected by their socio-economic background, as well as their genetic inheritance. The degree of inadequate physical development, physical deformity and an increased incidence of illness are closely related to the birth weight. The lower the birth weight, the greater the number

of inadequacies displayed by these children. The confusing part of the literature was the intermingling of the factors of genetics, socio-economic status, and low birth weight; all or any causing these children to be different physically and mentally from average birth weight children.

CHAPTER IV

METHOD

I The Sample

A. Age:

During the winter of 1963 a sample of low birth weight children born ten years earlier was selected. The hospital records of all children born in the University Hospital of Alberta from July, 1952, to March, 1954, whose birth weight was 2,500 grams (5 1/2 lbs.) or less were drawn. The original intention was to investigate a single year group; all children born in 1953. The total available for study in this year group was only 32, so the records of all children of the appropriate birth weight born between July, 1952, and September, 1954, were drawn for the study. (See Table 2.)

The Records Department presented only those files of children that were born alive. The mortality rate of these children during the first twenty-four hours of life is very high, so only those children who had lived at least twenty-four hours were considered. The illegitimate children in the above category were not used in the study because of the difficulty of tracing them through the various adoption agencies. Only 32 children could be traced so the same procedures were used for low birth weight children born from July to December in 1952, and from January to September, 1954. This brought the total number of

families drawn to 129. There were 30 singletons and 10 sets of twins, making a total of 50 in the sample.

The total number of children drawn by the Records Department was 129; four died during the first twenty-four hours, seven were illegitimate, four have died since, one was in the Provincial Training School at Red Deer, and one family refused to participate in the study. Of the 112 children remaining, 67 could not be traced; 45 were therefore available for study. They came from 35 families -- 10 pairs of twins and 25 singletons. The average age of the children in the sample was 10 years, 1 month; the oldest being 11 years, 9 months, and the youngest 9 years, 3 months.

TABLE 2

BIRTH DATES AND AGES OF THE SAMPLE

Birth Dates	Range of Ages in Years and Months	Number in Each Category
July 1952-Nov. 1952	11-9 to 11- 4	5
Dec. 1952-Apr. 1953	11-3 to 10-10	8
May 1953-Sept.1953	10-7 to 10- 4	13
Oct. 1953-Feb. 1954	10-3 to 9-10	1
Mar. 1954-July 1954	9-9 to 9- 4	14
Aug. 1954-Dec. 1954	9-3 to 8-10	4
Total		45

B. Birth Weights:

The birth weights of the sample ran from 1,446 grams (3 lbs. 3 oz.) to 2,528 grams (5 lbs. 9 oz). This one child who was 28.3 grams, or one ounce, heavier than the definition required was used because he was a twin of a true low birth weight child. (See Table 3.) The average weight of the sample was 2,044 grams (4 lbs. 9 oz.) at birth.

TABLE 3

BIRTH WEIGHTS OF THE SAMPLE

Weight in Grams	Number of Children
Less than 1740	7
1741 to 1940	3
1941 to 2140	9
2141 to 2340	16
2341 to 2540	10
Total	45

C. Socio-Economic Status:

The University Hospital in Edmonton does not attract a random sample of parents representing all socioeconomic conditions, but the following factors did show up in the study. The Out-Patient Department of the University Hospital does have a group of patients who cannot afford to pay their own medical expenses, so this does give a sample at the lower end of the socio-economic scale. Ten years ago many of the parents who are now successful

professional people were either students or struggling interns, who were certainly not earning a high salary.

The University Hospital does have a social status higher than any other hospital in Edmonton, so more of the professional people are represented in a sample of patients. The Doctors using the facilities of this hospital also appear to attract more of the University personnel, no doubt because of the various professional organizations on the campus. The ethnic background of the Doctors also has a bearing on the patients that are attracted to their practice.

The sample also appeared to contain cases that had been referred to the University Hospital because the local doctor suspected pre-natal problems beyond his scope; that is, some of these cases were referred for professional rather than economic reasons. The status of the University Hospital does give a sample of patients who expect better medical care than found elsewhere in the city. The above factors all tend to give a cosmopolitan, if not a completely random sample because of the kind of services offered.

The home environment of the sample was assessed by two criteria. The salary of the father was obtained by means of an interview questionnaire. (See Appendix A.) The salary range of the fathers ten years after the children were born ranged from $30,000 to $2,120 per year. The latter was the social welfare

allowance for a married man with one child in 1963. (See Table 4.)

TABLE 4

PARENTAL INCOME OF THE SAMPLE IN 1963

Annual Income	Number of Fathers	Number of Mothers (If Working)
Less than $3,000.	1	4
3,001. to 5,000.	11	2
5,001. to 7,000.	7	..
7,001. to 9,000.	3	..
9,001. to 11,000.	6	..
11,001. and above	7	..
Total	35	6

The education of the father and mother was also obtained by means of the questionnaire (See Appendix A.) and the range was from six years of schooling to six years of University. (See Table 5.)

TABLE 5

FORMAL EDUCATION OF PARENTS OF LOW BIRTH WEIGHT CHILDREN AS EVALUATED IN 1963

Formal Education	Number of Fathers	Number of Mothers
Grade VI to IX	13	6
Grade X to XII	10	21
Post High School	12	8
Total	35	35

II The Instruments

The intellectual capacity of the sample was measured by using the Wechsler Intelligence Scale for Children, (1949) published by the Psychological Corporation. This is a well known individual test that is suitable for the age of the sample. The WISC was used by Dockrell (1962) on a random sample of children of similar age in Edmonton, Alberta. His study was used as a comparison of intellectual capacity against results obtained from the low birth weight children.

The physical evaluation carried out at the University Hospital has no specific nomenclature, but it was standardized as much as possible. The Nelson (1963) scale was used as a basis of comparison of physical development. Other data collected during the physical examination were: birth order, parental age, total siblings (dead and alive), maternal health, serious illnesses, family history as well as a family tree for at least two generations. Observable physical defects were also noted. The birth weights were compared with Canadian norms as established by Spector (1961). (See Appendix B for a sample of the medical report.)

The evaluation of the home environment was in the form of an interview questionnaire. (See Appendix A.) The salary of the father, and mother if applicable, was determined, as well as the grade accomplishment of each parent at school. The amount of

schooling received by the parents appeared to be reflected very strongly in the home environment of the children. For example, the home conditions of a child whose parents were University graduates were markedly different from those whose parents had only Grade seven. The language in the home was also ascertained. The information gained on the questionnaire was checked against the recorded information gained by a personal interview by the medical examiners at the University Hospital. There was strong agreement between the objective measures of the questionnaire and the subjective assessment of the medical team.

III PROCEDURE

The Wechsler Intelligence Scale for Children was administered to the sample during the winter of 1963-64, and at the same time the medical examination was carried out. That is, the children were brought to the University in pairs, so that while one child was taking the WISC, the other was sent over to the University Hospital for examination, and the procedure reversed upon completion of testing. The parents were asked to fill in the questionnaire while at the Education Clinic, and the information was checked out during the personal interview at the Hospital.

The information on the home environment was divided into three categories: Group A, Group B, and Group C. To qualify for

Group C, the parental grade accomplishment was up to and including Grade IX; accompanied with this was a maximum annual salary of $5,000 per annum. The B category consisted of parental grades from Grade X to XII, and an annual salary from $5,001 to $9,000. The A Category was a grade accomplishment of over Grade XII, and a minimum salary of $9,001 per annum. There was only one father who had a salary of over $9,001 with a Grade IX education, but as his wife had a Grade XI education, he was placed in the B Category, as the home environment would presumably be above the C Category. (See Table 6.)

TABLE 6

GROUPING OF PARENTS OF THE SAMPLE ACCORDING TO HOME ENVIRONMENT

Type of Environment	Number of Homes
Group A	12
Group B	11
Group C	12
Total	35

The "Salary" classification was adapted from a number of factors all relating to home environment. The groups were arrived at by using tables prepared by the Dominion Bureau of Statistics (1961). The tables showed that all married males in Edmonton

between the ages of 35 and 44 earned an average wage of $5,008. per year in 1961. The sample of fathers of the children contained a number of self-employed as well as professional people, so it is hard to arrive at an average earning figure per year for any particular group. The unemployed, who obviously eat and live, are hard to evaluate on a type of dollar earning scale.

The grouping under these qualifications also took into consideration parental occupation. The professional people were primarily placed in Group A, the supervisory and lower management in Group B, and the unskilled as well as the unemployed were largely placed in Group C. These three main factors were all used in establishing the grouping of the parents for home environment.

Physical Assessment:

The "Health" classifications were designated by the medical axamination into below average, average, and above average. These designations were arrived at by using scales or norms, set out by Nelson (1963) for evaluating the physical development of children. This was on a percentile basis with the below average group, being under the 25th percentile, called the C Group. Group B was from the 25th to 75th percentile and Group A was above the 75th percentile. (See Table 7.)

TABLE 7

PHYSICAL ASSESSMENT OF THE SAMPLE
ACCORDING TO PERCENTILE

Percentile Rating	Number of Children
Less than 25 Percentile	16
26 to 75 Percentile	24
76 Percentile and over	5
	45

These percentiles were arrived at by the use of such measurements as present weight, height, body measurements of the head, chest and hips, signs of puberty, and other external factors also entering the scale. This was not a subjective analysis of the physical development.

The birth weights of the sample were divided into five groups. The lowest group was 1,740 grams (3 lbs. 14 oz.) or less, with an increase of 200 grams per group, up to the last group of 2,341 grams to 2,541 grams to 2,540 grams (5 lbs. 9 oz.). The average birth weight of the sample was 2,044 grams (4 lbs. 8 oz.). The lightest child was 1,446 grams (3 lbs. 3 oz.) and the heaviest was 2,528 grams (5 lbs. 9 oz.) at birth. (See Table 3, p. 31).

IV Statistical Analysis

The major statistical analysis was carried out at the Computing Centre at the University of Alberta on the IBM Computer, Model Number 7040. The programs used were prepared in the Department of Educational Psychology of the Faculty of Education.

There were three tests for significance and they are outlined below under Programs A, B, and C.

Program A:

The significance of difference between means were tested by using the two tailed t test, for the significance of differences between uncorrelated means. The formula as found in Ferguson (1959) p. 137, was used. The .05 level was taken as indicating statistical significance for the purposes of this study. The program was #1-918186.

Program B:

The significance of differences between the means of the number of different samples were tested by the analysis of variance using a one-way classification, as found in Ferguson (1959) p. 236. The F. ratio to test the homogenity of variance, or homoscedasticity, Ferguson (1959) p. 234, was also used to test the distribution of the variables in the population from which the sample was drawn to see if it was normal. The program used here was also #1-918186.

Program C:

The analysis of variance in a two-way classification with only one sample was used. Ferguson (1959) p. 246. There was one measurement for each condition, with the total sums of squares

being partitioned into three parts: a between rows, a between columns, and an interaction of the sums of squares were tested. There were unequal numbers in the sub-classes. The program used was #1-918173.

CHAPTER V

ANALYSIS OF THE DATA

Statistical analyses were carried out to determine the extent to which the test results would give support to the hypotheses in Chapter I. The hypotheses were divided into two main groups; intellectual and physical. The intellectual data were considered independently, and thus the correlation between the intellectual and physical data was calculated, to check to see of there is a significant difference between the various factors considered.

Intellectual Achievement:

The WISC was administered to the forty-five members of the original sample that were available for testing. The mean full scale score was 116.5, with a verbal scale score of 117.3 and a performance score of 112.4. Dockrell (1962), in his study in Edmonton of a random sample of ten and one half year old children, found the mean full scale score to be 115.3. This is a difference of 1.3 points which is not significant, using the t test at the .05 level.

The individual sub-test scores showed little difference with none significant. There was only one subtest score with a full number difference and that was on similarities. The standard deviation between the two groups showed no significant difference.

The figures are given in Table 8.

TABLE 8

A COMPARISON OF MEANS AND STANDARD DEVIATIONS ON THE WISC AS FOUND BETWEEN LOW BIRTH WEIGHT CHILDREN AND DOCKRELL'S (1962) SAMPLE AT TEN YEARS OF AGE

Sub-test	Low Birth Weight Children	Dockrell	Low Birth Weight Children	Dockrell
	Scaled Scores	Scaled Scores	Standard Deviation	Standard Deviation
F.S. I.Q.	116.6	115.3	13.5	11.4
Verb. I.Q.	117.4	113.7	13.6	11.9
Perf. I.Q.	112.5	114.3	12.6	12.5
Inform.	11.8	11.9	2.48	2.73
Compreh.	13.7	12.9	4.01	3.63
Arith.	12.3	11.9	2.87	2.60
Simil.	14.1	13.0	3.45	2.87
Vocab.	12.4	12.2	2.57	1.82
Digit S.	12.2	...	2.79	...
P.C.	13.1	12.6	3.82	3.36
P.A.	11.9	12.1	2.42	2.81
B.D.	11.6	11.6	2.56	3.13
O.A.	10.9	11.0	2.63	2.74
Coding	11.8	12.6	2.60	2.74

The low birth weight children had a minimum score on the I.Q. test of 85 points with a maximum of 138, giving a range of 53 points. The skewness of the plotted scores was minus .35. The standard deviation was 13.6. This indicates that a slightly larger proportion of the scores were above the mean score of 116.5 than

below it. (See Appendix C for results from Computer System.) The scaled scores, including all sub-tests, and the parents school achievement level as well as the salary grouping can be seen in Table 9.

The children's grades ran from Grade three in which there are two members of the sample, for their chronological age is nine years, four months, so these two children are not behind their age mates. There appeared to be approximately equal distribution for Grades five and six for there were twelve and thirteen respectively in each grade. Most of the children were ten years of age so that Grade four was the proper school grade for them. There is no evidence therefore of grade placement behind the normal. There is always the possibility of social promotion, though looking over the I.Q.'s of these children it appears unlikely.

TABLE 10

GRADE LEVEL OF THE SAMPLE

Grade	Number of Children
3	2
4	18
5	12
6	13
Total	45

Hypotheses Number 2 stated that the birth weight of low birth weight children will be correlated with the I. Q. The

TABLE 9

SCALED WISC SCORES AND PARENTAL GRADE AND SALARY

Child's I.D. No.	Verb.	Perf.	Full.	Inf.	Comp.	Arith.	Sim.	Voc.	Scaled	P.C.	P.A.	B.D.	O.A.	Cod.	Sal.	**Parent Grade M	F
1	121	188	119	10	12	13	15	15	16	6	13	12	12	16	B	10	12
2	99	96	97	8	7	10	11	11	12	11	9	11	9	7	C	6	10
3	85	89	85	9	8	5	7	7	9	5	11	10	10	6	B	9	9
4	123	117	122	11	20	15	13	11	11	14	11	14	13	10	C	11	11
5	119	106	115	10	17	11	15	13	12	17	8	10	11	9	B	9	9
6	129	133	134	14	16	10	19	13	15	19	12	14	15	12	A	10	U*
7	111	111	112	9	16	7	15	11	14	14	12	10	10	12	B	12	11
8	130	128	132	14	20	13	18	13	11	18	14	11	13	14	B	10	12
9	113	121	120	9	16	9	17	13	8	19	15	10	12	11	C	8	8
10	125	131	131	11	18	13	14	13	15	18	16	14	11	13	C	6	7
11	131	124	131	12	18	13	18	13	16	14	16	16	9	12	C	8	8
12	134	128	134	13	15	14	18	15	17	13	13	15	14	14	A	U	U
13	110	107	109	11	8	13	11	13	13	10	11	12	10	12	C	6	7
14	125	129	130	15	12	12	17	15	13	16	15	14	15	11	A	U	U
15	134	120	130	15	19	13	19	16	10	14	14	11	10	15	B	12	12
16	123	127	127	13	15	14	13	12	15	12	11	14	18	14	A	12	12
17	129	106	120	13	13	13	17	17	14	12	11	9	11	11	A	12	12
18	106	100	104	9	12	13	11	13	8	11	12	12	5	10	B	U	11
19	126	122	127	9	20	13	19	14	10	19	11	15	13	8	A	U	U
20	126	125	128	12	13	16	13	16	13	16	15	13	14	17	A	12	12
21	139	131	138	13	20	17	20	15	12	16	14	15	15	12	A	U	12
22	128	125	129	13	16	14	16	14	13	15	16	12	10	15	B	11	11
23	123	114	120	12	20	10	16	14	10	14	14	10	11	11	B	11	11
24	108	106	107	8	8	20	13	8	10	14	10	11	9	10	C	10	9

Note: ** Salary groups A - $9,001. and over
B - $5,001. to $9,000.
C - $ 0. to $5,000.

* U. stands for University training

TABLE 9 Continued

Child's I.D. No.	Verb.	Perf.	Full.	Inf.	Comp.	Arith.	Sim.	Voc.	Scaled	P.C.	P.A.	B.D.	O.A.	Cod.	Sal.	Parent Grade M	Parent Grade F
25	114	106	111	10	15	12	12	10	14	16	9	11	8	10	C	10	9
26	125	111	120	14	9	14	15	13	19	9	10	17	12	10	C	12	12
27	110	115	114	11	11	15	12	12	8	11	13	14	13	10	A	U	U
28	124	122	125	14	13	13	15	12	16	17	10	10	9	20	C	9	9
29	108	100	104	8	11	12	13	13	10	12	10	8	7	13	C	9	9
30	139	115	131	18	17	14	18	15	15	19	9	9	11	13	A	11	12
31	123	104	115	14	13	13	15	13	14	11	11	11	8	12	A	11	12
32	95	89	91	9	11	7	10	9	9	9	7	7	7	12	C	10	9
33	97	113	105	11	10	8	12	9	8	15	10	13	9	12	A	9	9
34	126	103	117	11	18	12	19	14	11	15	13	6	9	9	C	8	6
35	101	96	99	11	11	8	11	11	9	10	14	7	1	12	C	10	8
36	101	113	107	8	11	10	11	10	11	6	11	13	14	15	C	10	8
37	100	111	106	12	10	13	5	11	9	15	12	10	10	11	B	12	10
38	119	100	111	13	16	11	14	13	11	8	11	13	8	10	A	U	U
39	108	89	99	12	9	12	11	12	11	9	8	7	8	10	A	U	U
40	108	97	103	12	7	14	9	12	13	6	11	10	8	13	B	10	11
41	123	124	125	17	11	15	13	14	12	14	14	15	13	11	A	12	U
42	133	132	136	17	15	17	14	16	12	18	17	12	14	15	B	12	12
43	139	118	132	14	20	14	19	14	16	16	11	13	13	10	C	12	12
44	92	101	96	8	8	8	9	5	15	12	8	11	10	10	A	U	U
45	100	94	97	12	12	10	12	6	8	10	10	8	8	10	A	U	U

analysis of variance, with one way classification was used to check this.

The birth weights of the children were divided into five groups, starting with the lowest group of 1,446 grams (3 lbs. 3 oz.) to 1,758 grams (3 lbs. 14 oz.), with an increase of 200 grams (6 oz.) per group up to the heaviest of 2,381 grams (5 lbs. 4 oz.) to 2,551 grams (5 lbs. 10 oz.). (See Table 11.)

TABLE 11

GROUPING OF THE BIRTH WEIGHTS OF THE SAMPLE

Birth Weights	Number of Children
1,446 to 1,758 grams (3 lbs. 3 oz. to 3 lbs. 14 oz.)	6
1,786 to 1,956 grams (3 lbs. 15 oz. to 4 lbs. 5 oz.)	7
1,984 to 2,154 grams (4 lbs. 6 oz. to 4 lbs. 12 oz.)	8
2,182 to 2,353 grams (4 lbs. 13 oz. to 5 lbs. 3 oz.)	12
2,381 to 2,551 grams (5 lbs. 4 oz. to 5 lbs. 10 oz.)	12
Total	45

The analysis of variance for this data is clear. (See Table 12.) A test of goodness of fit was carried out and there is no evidence of non-normality of the I.Q. scores.

TABLE 12

THE RESULTS OF AN ANALYSIS OF VARIANCE BETWEEN THE FULL RANGES OF BIRTH WEIGHT AND I.Q.'S

Source of Variation	Sum of Squares	Degree of Freedom	Variance Estimate
Between	836	4	20.9
Within	7335	40	183.37
Total	8171	44	F =1.14

The value of F required for significance at the .05 level is 3.85. Therefore there is no significant relationship between birth weight and intelligence, so hypothesis number 2 was rejected.

The 3rd hypothesis stated that the development of low birth weight children will be a function of the home environment as measured by such factors as economic level, parental grade accomplishment and parental occupation.

This hypothesis was evaluated by the use of the analysis of variance using least squares with unequal N's. The data met the criteria of distribution necessary for this test. This technique was used because, according to Winer (1962) p. 186, the F test is more powerful than the corresponding q test. That is, the least squares analysis is more appropriate in the study than an unweighted means analysis.

The data, roughly called "Health", was put in the columns. The data "Salary" was put in the rows. There were three sub-divisions of each. The "Health" classifications were designated by the medical examination into below average, average, and above average. These designations are described above in Chapter IV, p. 37.

The "Salary" classification was adopted from a number of factors all relating to home environment. From this, three groups were evolved, and this is described above in Chapter IV, p. 36.

Table 13 gives a break-down of the groupings with columns indicating the three "Health" groups across the top. The "Salary" is in the row columns across the side, according to the groupings from the home environment factors. There was fairly equal distribution in all the cells except for A, where there was only one individual. This event does not occur very often, for it requires a child to be of the lowest grouping in "Salary" as well as the highest grouping in "Health". The opposite is much more apt to occur as found in Table 13.

The analysis of variance contained in Table 13 is presented in Table 14.

TABLE 13

THE DATA FOR THE ANALYSIS OF VARIANCE BETWEEN THREE DIVISIONS OF SALARY AND THREE DIVISIONS OF PHYSICAL DEVELOPMENT USING I.Q. AS A CRITERION

SALARY	CELL	HEALTH C	HEALTH B	HEALTH A	GRAND MEANS OF SALARY CELLS
S	C	104 122 107 120 131 91 ..	107 125 99 109 117 111 131	97	
		Mean = 110.8	Mean = 114.1	Mean = 97	107.1
A L A R Y	B	103 130 120 119 106 85 132	104 129 120 132 112 125 115 136 127	134 120	
		Mean = 113.5	Mean = 122.2	Mean = 127	120.9
	A	111 96 97	130 138 99 128 115 127 114	105 131 134	
		Mean = 100.7	Mean = 121.5	Mean = 120.1	115.1
GRAND MEANS OF THE HEALTH CELLS		108.3	119.2	115.7	116.5

TABLE 14

THE ADJUSTED ANALYSIS OF VARIANCE

Source of Variations	Sum of Squares	Degree of Freedom	Variance Estimate
Rows (Salary)	368/04	2	184.02
Columns (Health)	755.20	2	377.60
Interaction	929.50	4	232.37
Within Cells (error)	6070.70	36	168.63

The data had to be adjusted because there was an unequal number of cases in each cell. This adjustment does not change the cell means, or the rows or columns means.

The interaction between the "Salary" and the "Within Cells" is found by $\underline{F} = \frac{184}{16863} = 1.09$. To be significant $\underline{F}$ at the .05 level for a df of 2/36 must equal 3.26. The difference is not significant.

The interaction between the "Health" and the "Within Cells" is $\underline{F} = \frac{377.60}{168.63} = 2.24$. For $\underline{F}$ to be significant at the .05 level for df of 2/36 must equal 3.26. The difference is not significant.

For the interaction between "Health" and "Salary", $\underline{F} = \frac{232.38}{168.32} = 1.38$. For $\underline{F}$ to be significant at the .05 level, a df of 4/36 must equal 2.63. The difference is not significant.

We may therefore conclude that there is no significant relationship between physical development, environment and I.Q., for this sample. Nor do physical development and home environment

jointly affect the I.Q. for this group. Therefore the third hypothesis is rejected.

Hypothesis number 4 stated that low birth weight children have a higher incidence of inadequate physical development, physical deformity and an increased incidence of illness over that of mature children of the same age.

The percentile scores were grouped into the three levels as described above in Chapter IV, p. 38.

The number of children in each group is given in the following table:

TABLE 15

GROUPINGS OF LOW BIRTH WEIGHT CHILDREN AS TO PHYSICAL DEVELOPMENT

Group	Percentile	Number of Cases	Male	Female
I	0 - 25	16	10	6
II	26 - 75	24	8	16
III	76 - 100	5	3	2
Total		45	21	24

The Chi Square test was applied to this data and it showed no significant difference between the percentile rating of the boys and girls. The low birth weight children did not differ significantly from the national norms.

Twins and Singletons:

The sample contained a high proportion of twins.

There were ten sets of twins as compared to thirty single births. There was no specific hypothesis set up to compare these groups on intelligence but they were tested to see if there was a significant difference using the t test, and there was no significant difference.

Birth Weights:

The girls and boys of the sample were separated as to birth weight. The mean birth weight of the girls was 4.70 pounds. The boys mean birth weight was 4.69 pounds. It is obvious there is no significant difference between the birth weight of the two sexes.

Drillien (1964) stated that mature male infants weighed 3 to 4 ounces more at birth than females for the same given gestation period, and it is generally assumed that for like birth weights, females are slightly more mature than males. She found that in premature children of 28 to 35 weeks of gestation time there was little difference in weight between male and female.

The findings of this study agree with that of Drillien in that there is no significant difference between the birth weight of male and female infants.

CHAPTER VI

SUMMARY AND DISCUSSION

This study has attempted to evaluate the intelligence rating of low birth weight children as compared to mature birth weight children. The conclusions are based on an analysis of the data pertaining to home environment and physical development. They are discussed in terms of their relation to each hypothesis, and then summarized in general terms. Most of the implications arising out of the findings are noted, as well as their limitations. Suggestions for further research are also included.

I Specific Conclusions

Hypothesis 1:

There are no significant differences between the intelligence ratings of low birth weight children and mature children at ten years of age in an Edmonton sample. Therefore the hypothesis was rejected.

The relevant literature stated that low birth weight children have a discrepancy of five to ten points on intelligence ratings when compared with mature children. The explanations offered for this similarity in I.Q. rating between the two groups are controversial. The literature does suggest that from birth on-wards, there is a continual upgrading of the children in this

category. Perhaps by ten years of age the low birth weight children have caught up to their peers in the general population.

Another factor in this study was the selection of the sample. The random sample used as a basis of comparison selected by Dockrell (1962) was of the same geographic area and of the same cosmopolitan nature. Cropley (1964) used a follow-up study on Dockrell's sample in evaluating the effect of socio-economic factors upon intelligence ratings.

Judging from the results of both studies it would seem that there was very little difference in the home environment of the two groups. This is an area where it is hard to measure the actual differences for there are a large number of factors that enter into the area of home environment.

The low birth weight children had a mean Full Scale score of 116.6 on the WISC. Dockrell's group were 115.3 on the same scale. This is not a significant difference on a sample of this size. The difference between the means on the Verbal I.Q. score was found to be 3.7 points, with Dockrell's sample being lower. Cropley found that the correlation tended to be higher between verbal sub-tests and socio-economic status than for the performance sub-tests. He also confirmed that in his sample there is a significant relationship between social status and intelligence. Cropley found a correlation between these factors of .31 to .52, which was consistent with the literature on the subject.

Dockrell's groups had a higher Performance I.Q. score of 2.3 points on the mean score over the low birth weight children. The factors of a higher mean Verbal score and lower mean Performance score suggest that the home environment of the lower birth weight children may have been higher than those of Cropley's sample. It is hard to find effective measurement units for socio-economic status, so subjective comparisons can only be made from two samples.

Hypothesis 2:

There is no correlation between the I.Q. score of low birth weight children and their birth weight, when their birth weights are sub-divided into five groups. Therefore, the hypothesis was rejected.

The group of children with the lowest birth weights of 1,446 grams (3 lbs. 3 oz.) to 1,758 grams (3 lbs. 14 oz.) were taken and then I.Q.'s were compared to the I.Q.'s of the children in the other four groups. There was no significant difference between any of the groups. The birth weights of the heaviest group of children ranged from 2,381 grams (5 lbs. 4 oz.) to 2,551 grams (5 lbs. 10 oz.). The normal mean birth weight for children of mature weight is 3,200 grams (7 lbs. 1 oz.) The lower birth weight does not appear to affect the Intelligence rating of the low birth weight children, regardless of the grouping.

The relevant literature all states that the lower the

mean birth weights, the lower the mean intelligence scores. Drillien (1962) found that in a sample of 66 school age children of birth weights of 3 pounds or less, only six scored over 100 on an I.Q. rating. She also found that 22 of the group are ineducable in a normal school for reasons of physical or mental defects, or both. The birth weight of the smallest child in the sample tested for this study was 3.3 pounds, and interestingly enough, this child had an I.Q. of 130 on the WISC.

Crosse (1960) found in a sample of 5,078 European infants of low birth weight that 1.6 percent are below 3 pounds at birth. This is likely why the study contained no children below 3 pounds at birth, due to the small size of the sample. The medical literature does show that the highest incidence of physical defects and abnormalities occurs in the children of lowest birth weight.

The proportion of retarded children reported in some research (Drillien, (1964) and Silverman (1961)) is larger than that found in this study. There was one child in this study who was in the retarded range, thus making up two per cent of the sample. This comes very close to the national average. There is also the factor of four dead children, which makes a death rate of eight per cent, which is many times higher than the national average for children up to ten years of age. It could be that some of these children who died were retarded and died shortly

after birth. The present day of better child care, permitting more of the retarded children to survive the first ten years of life, can also be an influence on the percentage of retarded children in present studies.

Hypothesis 3:

The home environment does not show a significant difference in the development of low birth weight children. The hypothesis was therefore rejected.

The data obtained on home environment were divided into three groups; roughly representing the above average, average, and below average. In the latter group it is hard to distinguish, in dollars and cents, the difference between an unemployed father and one doing unskilled labour on a part-time basis, for they are both managing to exist. The difference in attitude between these parents is much harder to measure; perhaps this is a far more important feature. This determination of the unskilled father to continue struggling must mean something and have an effect on the attitude of the child.

The school grade achievement of the father and mother played an important part in determining the home environment grouping. The below average group was made up of parents whose grade accomplishment was less than Grade X. The average group

contained the parents who had most of their high school education, and the above average group included those parents who had post high school training.

The school grade accomplishment of the parents paralleled very closely the salary of each group. There was only one case where a parent with a very low education was making a large salary. Most of the top wage earners were professional people, just as most of the bottom group were the unemployed and unskilled labourers. The medical team also evaluated the home environment of each family, by taking a subjective measure of the description of the home environment of each child. This paralleled very closely the grouping obtained by using the above data.

The physical development measures at ten years of age of low birth weight children were divided into above average, average and below average groups. The actual measurements of such things as height, weight and body measurement as compared to national norms were used to interpret the above data as objectively as possible. Here again, many factors enter into the measuring in units of human beings. The race, nourishment, and parental size all markedly affect bodily growth. Averages seem to be the only method and yet they are not completely satisfactory.

A comparison of the means of the weights of the sample as against national norms established by Nelson (1963) shows that the sample is very close to the national norms. The boys in the

sample had a mean weight of 67.7 pounds; the mean for the norms was 70 pounds. The mean height of the boys was 54 inches, whereas the mean for the norms was 53.1 inches in children at ten years of age.

The mean weight of the girls was 69.2 pounds as compared to the mean of the norms of 69 pounds. The mean of the heights of the girls was 54.5 inches, and the norms was 53.3 inches. From this data it is apparent that the sample was an inch taller than the average. The boys appear to be lighter and taller than the national norms, on the average.

The correlation between home environment, physical development and Intelligence Quotient was calculated by using the analysis of variance. There was no significant difference for the factors concerned. The I.Q. score had a range from 85 to 138 on the WISC, so it would appear that there has to be some factor besides home environment and physical development producing this large range in scores. For this group the home environment did not have a deleterious effect upon the intellectual or physical development of the children.

Hypothesis 4:

Low birth weight children do not have a higher incidence of inadequate physical development, physical deformity or an increased incidence of illness than do mature children of the

same age. The hypothesis was rejected.

Extremely low birth weight; that is, under three pounds, is associated with a far higher incidence of physical deformity than other birth weights. Drillien (1961), in her study of 110 children with birth weights of under three pounds, found that three quarters of these children, upon reaching school, had some physical development and/or mental retardation. She also found that of this group, only nine per cent scored 100 or over on an intelligence test. The obstetrical history of the mothers showed that they had an excess of losses in other conceptions as compared to a group of control mothers.

All the children of this sample were over three pounds at birth and this perhaps explains why there was not a significant amount of physical deformity present in the group. The only physical defect that was present was a much higher proportion of myopia than found in a group of mature children of the same age. Twenty-two children in the sample had myopia. One child had vision in only one eye, thirteen had severe myopia, seven had mild myopia and one suffered from astigmatism. Silverman (1961) reported that research points to a connection between the amount of oxygen supplied to premature infants and some of the physical defects found in these children.

The medical examination team also observed the children

having a higher incidence of emotional disturbance than a similar group of mature ten year old children. This is a factor that is extremely hard to measure in terms of units. The whole field of personality evaluation is of a subjective nature at the best of times. The medical team reported that there was frequently an association of emotional disturbance in both parents and child but this was not always the case. Some of the parents were undergoing psychiatric treatment, but there did not appear to be any sign of emotional disturbance in their children. There are tests available that can evaluate emotional problems to a degree, but they were not used in this study.

The degree of increased illness that was suspected in the sample was not present to any degree of significance. Most of the children had undergone the usual childhood diseases, and recovered successfully, and there was no history of continual illness in any member of the group.

The literature does suggest a large amount of illness during the first year of life; and the medical history of the sample bears this out. As the children become older, they seem to grow out of these illnesses and to resemble their peers, with no more and no less incidence of illness.

II General Conclusions

The low birth weight children performed equally well on the intelligence tests, when compared to the children of average birth weight. Drillien (1964) found a higher incidence of inferior mental ability in very low birth weight children, but suggested that as the children get older they approach the level of ability of their peers. The data shows that by ten years of age they have reached the equal of their peers.

The information gained in the study shows that low birth weight within this range is not correlated with the I.Q. score. The higher incidence of school failure expected does not take place among the children of the sample.

The four hypotheses set out in Chapter I are in Table 16. The inference to be drawn from this table is that low birth weight children appear to have the same chance for a normal school career as other children, for their intellectual, physical and home environment are all comparable, on the basis of the sample of children at ten years of age.

TABLE 16

A SUMMARY OF THE HYPOTHESES, CONCLUSIONS AND IMPLICATIONS OF THIS STUDY

Hypothesis	Rejected or Accepted	Conclusions	Implications
1. Low birth weight children perform lower on WISC	Rejected	Apparently I.Q. is not correctly measured. It changes with growth.	Should be treated the same as mature children
2. Low birth weight is correlated with I.Q. score	Rejected	Appeared to be no correlation	Should be treated the same as mature children
3. Low birth weight children have a differential development because of home environment	Rejected	I.Q. and physical development appear to be the same regardless of home environment	Once low birth weight children have started school they do not require extra care or help
4. Low birth weight children have a higher incidence of physical deformity, inadequate development and illness	Rejected	These children are slightly smaller but do catch up in growth. No serious physical defects, except myopia	There appears to be no more incidence of physical deformity that will hinder normal development, except myopia

III Implications

The low birth weight children should retain the same chance for a normal school career as any other child. The child has a similar I.Q. rating and therefore should be treated the same as mature children of the same age, at school and in all other intellectual training that is available.

Once a low birth weight child emerges from the extreme post natal care that seems necessary for him, then he should receive the same care and nourishment as other children.

The home environment of low birth weight children does not preclude a higher or lower physical or intellectual development. These children should not be rejected for this investigation suggests that they do have the same intellectual and physical potential. True, the intelligence rating is not the only factor that makes a good student or a successful entrepreneur in business, but the literature on school achievement today points very strongly in this direction.

The physical development and incidence of illness found in the sample points to the fact that these children are at a par with a similar group of mature children. They should be reared with the same general care. The incidence of myopia should be kept in mind, with perhaps more frequent ophthalmological examinations than for other children. The emotional control of these children

as with other children who have emotional problems, would suggest careful handling in stressful situations.

IV Limitations of this Study

The need to study the individual behaviour of these children, in the school room, becomes very evident. A detailed analysis of the school achievement of these children will yield useful information for educational guidance. The study was limited in that it did not do so.

Another limitation of this study was an inadequate measure of the emotional stability of the children. The WISC scores can point toward suspected asphasia but they do not predict emotional disturbances with any degree of accuracy. The degree of emotional disturbance was limited to a subjective evaluation of the medical examiners.

The range of weights at birth of these children limited the study in comparison to work done by other researchers. There was not one child under three pounds at birth in the sample and this appears to be the group with the greatest number of intellectual and physical defects. The individual child received a thorough medical and intellectual examination but not in a justifiable form to study the emotional problems of low birth weight children.

V Future Research

There is much information available from work done on this study that was not used that could possibly be of use in a follow-up study of these children in five or ten years. The parents have already been asked if they would co-operate and they have all agreed. The school achievement as well as the physical development would be much easier to evaluate at twenty years of age. The results obtained when these children are twenty years of age might show that low birth weight alone is not a detriment to normal development.

Another interesting theme to investigate would be the factors associated with prematurity. The following is a list of suggested such factors, but each one needs further investigation:

1. Racial and geographic difference
2. Sex differences
3. Multiple births
4. Birth rank and social class
5. Age of the mother
6. Legitimacy
7. Complications of pregnancy
8. Gestation time
9. Smoking

Further investigation into the family tree and medical history of the families encountered in this study could bring out some interesting data. There appears to be unknown factors causing prematurity in some cases which continue to affect the normal

development of the children. If this is a hereditary factor, further research on this could be of tremendous importance in helping others. More detailed studies of academic achievement and emotional adjustment might yield valuable information for the guidance of parents. Future studies should include a more representative sample of socio-economic and ethnic groups in the population if possible, as well as all surviving children including the illegitimate children that could be traced.

BIBLIOGRAPHY

BIBLIOGRAPHICAL ENTRIES

A. BOOKS

Binet, A. and Simon, T. L. (1905). Nouvelles Recherches sur La Mesure du Niveau Intelligence chez les Enfants d "Ecole", L'Annee Psychologique XVII, pp. 145-201.

Douglas, J. W. B. and Blomfield, J. M. (1958). Children Under Fire, London: Allen & Unwin.

Drillien, C. M. (1964). The Growth and Development of the Prematurely Born Infant, Edinburgh: E. & S. Livingstone Ltd.

Ferguson, George A. (1959). Statistical Analysis in Psychology and Education, New York: McGraw Hill.

Gesell, A. and Amatruda, C. (1941). Developmental Diagnosis, New York: P. B. Hoeber.

Hebb, D. O. (1958). A Textbook of Psychology, Philadelphia and London: W. B. Saunders Company.

Hess, J. H., Mohr, G. J., and Bertelme, P. F. (1934). The Physical and Mental Growth of Prematurely Born Children, Chicago: University Press.

Illingworth, R. S. (1963). The Development of the Infant and Young Child, Normal and Abnormal, Edinburgh: E. & S. Livingstone Ltd.

Lubchenko, L. O. (1962). The Relationship of Fetal Size to Later Physical Growth of Prematurely Born Children. (In the Press.)

Silverman, W. A. (1961). Dunham's Premature Infants, 3rd Edition, New York: Hoeber Inc.

Spector, W. S. (1961). Handbook of Biological Data, Philadelphia and London: W. B. Saunders Co.

Terman, L. M. and Merrill, M. A. (1937). Measuring Intelligence, Boston: Houghton Mifflin.

Wechsler, D. (1949). Wechsler Intelligence Scale for Children, New York: The Psychological Corporation.

B. PERIODICALS

Alm, I. (1953). "The Long Term Prognosis for Prematurely Born Children." Acta. Paediat., (Uppsala), Suppl. 94.

Asher, C. and Roberts, J. A. F. (1949). "A Study on Birth-weight and Intelligence." British Journal of Sociological Medicine. 3:56.

Benton, A. L. (1940). "Mental Development of Prematurely Born Children." A Critical Review of the Literature. American Journal of Orthopsychiatrics. 10:719.

Belgen, S. D. (1953). "The Premature Child." The incidence of aetiology, mortality and the fate of the survivors. Acta. Paediat. 42. Suppl. 88.

Beskow, B. (1949). "Mental Disturbance in Premature Children at School Age." Acta. Paediat. (Stock.) 37:125.

Cropley, A. J. (1964). "Differentiations of Abilities, Socio-economic Status and the WISC." Journal of Consulting Psychology. Feb., 1964.

Crosse, V. M. (1960). Public Health Aspects of Low Birth-Weight. World Health Organization, Expert Committee on Maternal and Child Health. Geneva 21-26, Nov., 1960.

Dann, M., Levine, S. Z., and New, E. V. (1964). "A Long Term Follow-up of Small Premature Infants." Journal Paediat. 33:6.

Dockrell, W. B. (1962). "A Comparison of the Performance of Education on American Ten and One Half Year Old Children on the WISC." Canadian Education and Research Digest. III, March, 1962.

Douglas, J. W. B. (1950). Some Factors Associated with Prematurity. The Results of a National Survey. J. Obstet. Gynaec., British Empire 57, 143.

Douglas, J. W. B. and Mogford, C. (1953). "Health of Premature Children from Birth to Four Years." British Medical Journal. 1:748.

Douglas, J. W. B. (1956). "Mental Ability and School Achievement of Premature Children at Eight Years of Age." British Medical Journal, 1210.

Douglas, J. W. B. (1960). "Premature Children at Primary School." British Medical Journal. 1:1008.

Drillien, C. M. (1958). "Growth and Development in a Group of Children of very Low Birth Weight." Archives of Diseases of Childhood. 33:10.

Drillien, C. M. (1959). "A Longitudinal Study of the Growth and Development of Prematurely Born Children." Part III. Mental Development. Archives of Diseases of Childhood. 33:423.

Drillien, C. M. (1961). The Incidence of Mental and Physical Handicaps in School-Age Children of very Low Birth Weight. Pediatrics. 27:452.

Drillien, C. M., Ingram, T. T. S., and Russell, E. M. (1962). Comparative Aetiological Studies of Congenital Dyslegia in Scotland. Archives of Diseases of Childhood. 37:282.

Eames, T. H. (1955). "The Relationship of Birth Weight, The Speed of Object and Word Perception and Visual Activity." Journal of Pediatrics. 46:603.

Falkner, F. (1957). "Some Physical Measurements in the First Three Years of Life." Archives of Diseases of Childhood. 33:1.

Falkner, F. (1961). Office Measurement of Physical Growth. Pediat. Clin. North America. 8, 13.

Fraser, M. S. and Wilkes, J. (1959). "The Residual Effects of Neonatal Asphyxia." Journal of Obstetrics and Gynaecology. British Empire. 66:748.

Garn, S. M. and Rohmann, C. G. (1959). "Communalities of The Ossification Centres of the Head and Wrist." American Journal of Phys. Anthrop. 17:319.

Hebb, D. O. and Morton, N. W. (1944). "Notes on the Measurement of Intelligence of Adults." Journal of General Psychology. 30:217-223.

Illingworth, R. S. et al. (1950). "The Relation of Birth Weight to Physical Growth." A Statistical Study. Archives of Diseases of Childhood. 25:380.

Illingworth, R. S. et al. (1956). "Neuropsychiatric Sequelae of Prematurity." Journal of American Medical Association. 161:581.

Smith, C. A. (1962). "Prenatal and Neonatal Nutrition." Borden Award Address. Pediatrics, 30:145.

Spohn, P. A. (1950). "The Adequate Care of the Premature Infant." Canadian Medical Association Journal. 62:317.

Tanner, J. M. et al. (1956). "The Aberdeen Growth Study." Archives of Diseases of Childhood. 31:372.

Walker, W. L. (1963). "Congenital Defects Associated with Prematurity." Archives of Diseases of Childhood. 37:277.

Ylpp'o, A. (1919). "Das Wachstum der Fruhgeborenen von der Geburt bis zum Schilater." Growth of Prematures from Birth to School Age. ZTSCHR. Kinderh. 24:111.

C. PUBLICATIONS OF GOVERNMENT AND OTHER ORGANIZATIONS.

American Academy of Pediatrics (1964). Standards and Recommendations for Hospital Care of Newborn Infants. American Academy of Pediatrics Inc. Evanston, Ill.

Dominion Bureau of Statistics (1961). Wage Earners, by Marital Status during the 12 months prior to the Census Date June 1, 1961.

Knoblock, H. and Pasamanuik, B. (1950). "Distribution of Intellectual Potential in an Infant Population." From Epidemiology of Mental Disorder. American Association of the Advancement of Science.

United Nations Handbook of Vital Statistics Methods (1955). Studies in Methods, Series I. New York Statistical Office of the United Nations.

World Health Organization (1961). Public Health Aspects of Low Birth Weight. Third Report of Expert Committee on Maternal and Child Health. World Health Organization Techn. Rep. Ser. No. 217.

APPENDIX

APPENDIX A

QUESTIONNAIRE

Occupation of father_____

Occupation of mother (before marriage)_____

Present occupation of mother, if working_____

Approximate income_____

Do you use a language other than English in your home?
If you do,

(a) name it_____

(b) circle the words which tell how often you use it.

Hardly ever Quite often Most of the time

Highest grade father reached in school_____

If beyond Grade XII state_____

Highest grade mother reached in school_____

If beyond Grade XII state_____

School presently attended by child_____

_____

Parents' Name_____

Child's Name_____

APPENDIX B

PREMATURE FOLLOW UP

PHYSICAL EXAMINATION

NAME D.O.B.

Ht. Head circ.

Wt. Chest circ.

Span. Hip circ.

U.S./L.S. Somatotype.

Ears

Nose

Throat

Heart

Lungs

Abdomen

Genitalia

Muskuloskeletal

C.N.S. Vision K.J.

Squint A.J.

Hearing Plantars

Speech

Coordination

Address for follow up:

Final Assessment.

APPENDIX B Page 2.

PREMATURE FOLLOW UP

FAMILY HISOTRY

NAME D.O.B.

Total Maternal Obst. History (Including Misc. S.B.'s Neo-Nat. D. Gest. B. Wts.)

(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)

Maternal Health (Before, During, and Since This Preg.)

Economic Social (Income, Home, Clothes, Food, Car etc.)

(1) Prior to this preg.

(2) Since

Health of Other Members Family

Genetic Father. (Ht. & Wt.) Mother (Ht. & Wt.)

Siblings.

Mat. Aunts.

Pat. Aunts.

APPENDIX C

PROGRAM RESULTS 1-918173

SAMPLE SIZE	45
MINIMUM	.85000000E+02
MAXIMUM	.13800000E+03
RANGE	.51000000E+02
CLASS WIDTH	.25500000E+01
MEAN	.11655555E+03
MEDIAN	.11840500E+03
MODE	.11942500E+03
VARIANCE	.18570704E+03
ST. DEV.	.13627437E+02
SKEWNESS	-.35744611E+00
KURTOSIS	-.99124458E+00

APPENDIX C

PROGRAM RESULTS 1-918186

```
LOAD FORTRAN EXECUTE
HIGHEST LOCATION LOADED = 33559.
NEXT AVAILABLE LOCATION BELOW COMMON = 54999.
WITHIN CELL SUMS AND SUMS OF SQUARES
```

J	K	NO	SUMS	SQUARES	CELL SQUARED
1	1	6	6.7500000E+02	7.6991000E+04	7.5937500E+04
1	2	7	7.9900000E+02	9.1927000E+04	9.1200142E+04
1	3	1	9.7000000E+01	9.4090000E+03	9.4090000E+03
2	1	7	7.9500000E+02	9.1955000E+04	9.0289285E+04
2	2	9	1.1000000E+03	1.3530000E+05	1.3444444E+05
2	3	2	2.5400000E+02	3.2356000E+04	3.2258000E+04
3	1	3	3.0400000E+02	3.0946000E+04	3.0805333E+04
3	2	7	8.5100000E+02	1.0447900E+05	1.0345728E+05
3	3	3	3.7000000E+02	4.6142000E+04	4.5633333E+04

```
SSAB
6.1343430E+05
```

```
COLUMN SUMS AND SUMS OF SQUARES
```

K	NO	SUMS	SQUARES	COLS SQUARED
1	16	1.7740000E+03	1.9989200E+05	1.9669225E+05
2	23	2.7500000E+03	3.3170600E+05	3.2880434E+05
3	6	7.2100000E+02	8.7907000E+04	8.6640166E+04

```
SSB
6.1213675E+05
```

```
ROW SUMS AND SUMS OF SQUARES
```

J	NO	SUMS	SQUARES	ROWS SQUARED
1	14	1.5710000E+03	1.7832700E+05	1.7628864E+05
2	18	2.1490000E+03	2.5961100E+05	2.5656672E+05
3	13	1.5250000E+03	1.8156700E+05	1.7889423E+05

```
SSA
6.1174959E+05
```

```
TOTAL SUM AND SUM OF SQUARES
```

NO	SUMS	SUM SQUARES	TOT SQUARED
45	5.2450000E+03	6.1950500E+05	6.1133388E+05

```
N PRIME
 1.0014042E+01-8.1153846E+00-1.8986567E+00
-8.1153846E+00 1.1230770E+01-3.1153846E+00
-1.8986567E+00-3.1153846E+00 5.0140416E+00

B Prime
-8.6930900E+01 6.8846200E+01 1.8084880E+01
```

APPENDIX C Program Results 1-918186 Continued:

1.0000	0.0000	0.0000	71.5200
0.0000	1.0000	0.0000	80.1356
0.0000	0.0000	1.0000	80.4800

BETA

7.1520010E+01
8.0135621E+01
8.0480000E+01

UNADJUSTED SUM OF SQUARES

SSA	4.1571000E+02
SSB	8.0287000E+02
SSCEL	2.1004200E+03
ERROR	6.0707000E+03

ADJUSTED ANALYSIS OF VARIANCE

SOURCE	SS	DF	MS
SSA	3.6804520E+02	2	1.8402260E+02
SSB	7.5520520E+02	2	3.7760260E+02
SSAB	9.2950480E+02	4	2.3237620E+02
ERROR	6.0707000E+03	36	1.6863055E+02

Salary A $F = \frac{184.02}{168.63} = 1.09$ F.05 2/36 = 3.26 NS

B $F = \frac{377.60}{168.63} = 2.24$ F.05 2/36 = 3.26 NS

AB $= \frac{232.38}{168.63} = 1.38$ F.05 4/36 = 2.63 NS